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VITALITY OF PINE SEEDS AND THE DELAYED OPENING OF CONES

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ON a visit to California in July, 1908, my curiosity was aroused by the remarkable retention of the still unopened cones in *Pinus attenuata* (*P. tuberculata*) the knob-cone pine, and to a somewhat less conspicuous degree in the Monterey pine (*Pinus radiata*). Trees of *Pinus attenuata* may frequently be seen several feet in diameter and thirty or forty years old, still retaining unopened all the cones they have produced during their lives, the lowest cones circling the tree within hand's reach from the ground. As all cones are borne on new growth it is obvious that as the branches increase in thickness the peduncles of the cones must be broken loose from their connection with the wood, so as to allow the cones to be pushed out by the annual growth, or the cones will be covered as the tree develops and finally imbedded in the wood. As the cones of *P. attenuata* are narrow at the base and thus more easily caught by the annual layers, the latter alternative sometimes occurs and the cones are covered by the growth of the tree.

The cones that remain on the surface of the trunk and branches have no organic connection with the tree, and their peduncles, which are almost an inch long, may be twisted out like a cork from a bottle. It is a well-known fact that in this case the cones never shed their seeds until the tree or branch that bears them dies.

This remarkable peculiarity is exhibited to almost as great a degree by *Pinus radiata* (Monterey pine). Of this tree J. G. Lemmon says:¹

¹ *Sierra Club Bulletin*, Vol. 2, p. 74, 1897.

Trees four and five inches in diameter may be seen on Point Pinos, still retaining every cone they have produced, circling the trunk and limbs from base to apex. Of course the lumber is perforated with holes, the channels formed by the cone-stems on their many years' journey from heart to bark.

Other species of western American pines whose cones are serotinous to a greater or less degree are *P. muricata*, *P. contorta*, *P. contorta* var. *Murrayana* (the lodge pole pine) and *P. chihuahuana*. Of *P. muricata* Lemmon says:² "The cones have been known to remain unopened for twenty or thirty years, then to release good seeds," but he says in another place of the cones of the same tree:³ "They usually open at the time the leaves at the same point fall away from the stems." The *Gardener's Chronicle* for April 24, 1909, gives a good illustration of this pine showing old unopened cones, and in the same number, Mr. W. J. Bean says: "Some of the trees at Kew bear cones which must have developed more than a quarter of a century ago."

Of the eastern American pines the only ones to retain their cones unopened after maturity are the jack pine (*P. Banksiana*) of the north, the Table Mountain pine (*P. pungens*) of the Alleghanies, the pond pine (*P. serotina*) of the southern states, and *P. clausa* of the gulf coast and eastern Florida. In the case of the last species the cones may become imbedded in the wood as in *P. attenuata*.⁴

That this remarkable habit of cone retention is of use in the struggle for existence, at least under the peculiar conditions that exist in our western country, is believed by a number of observers. The explanation that is usually offered is well expressed by John Muir in "Our National Parks" page 104. Speaking of *Pinus attenuata* (under the name of *P. tuberculata*) he says:

² "Handbook of West American Cone-bearers," 3d ed.

³ *Erythea*, Vol. 2, p. 160, 1894.

⁴ In *Garden and Forest*, Vol. 10, p. 232, Professor C. S. Sargent remarks that cones of *P. muricata* often become imbedded in the bark, but in a letter to me he says that this "appears to be erroneous."

This admirable little tree grows on brushy, sun-beaten slopes, which from their position and the inflammable character of the vegetation are most frequently fire-swept. These grounds it is able to hold against all comers, however big and strong, by saving its seeds until death, when all it has produced are scattered over the bare cleared ground, and a new generation quickly springs out of the ashes.

This statement of Mr. Muir's implies that all or a large part of the seeds produced during the life of the tree are capable of germination when shed, and this seems to be the opinion of others (see Lemmon, as quoted above, under *P. muricata*).⁵

Now it is a well-known fact that pine seeds as a rule are very perishable (seeds of *P. palustris* will not germinate, according to my experience, the second spring after their maturity) and it is important to test by actual experiment to what extent seeds retain their vitality under such conditions. In looking over the literature I can find but one experiment that has been made to enlighten us on this point.

In 1874 Dr. Engleman collected a branch of *Pinus contorta* from Colorado (the plant being probably var. *Murrayana*, or lodge pole pine) and after keeping it four and a half years, he sent it to Professor C. S. Sargent, of the Harvard Arboretum, to test the seeds. Professor Sargent planted the seeds in 1879, and his results, as reported in *Bot. Gazette*, Vol. 5, p. 54, 1880, were as follows:

⁵ The reference to *Pinus radiata* by Vernon Bailey on page 34 of C. Hart Merriam's "Results of a Biological Survey of Mount Shasta, California" (*North American Fauna*, 16, 1899) would indicate that its seeds have a hard time on Mount Shasta. He says:

"The trees were loaded with cones, in whorls of three to seven around the branches, and down the trunks to 10 or 12 feet from the ground. Some of the cones must have been 20 or 30 years old, and perhaps much older. I cut off a lot of the old lower cones to see if the seeds were good, and put them on a boulder and cracked them with a few hard blows of the ax. All of them were full of worm dust, with only now and then an undiscovered seed or a fat white worm. Cones of medium age (5 or 6 years back from the end of the branch) were invariably occupied by worms and worm dust, and usually contained few good seeds. Cones only 1 or 2 years old were rarely wormy. A great many of the old cones had been dug into by woodpeckers, either for seeds or, more likely, for the fat white grubs that live on the seeds."

Seeds of 1865 and 1868 did not germinate.
1869 24 seeds planted, 4 germinated.
1870 25 seeds planted, 4 germinated.
1871 6 seeds planted, 2 germinated.
1872 19 seeds planted, 5 germinated.
1873 9 seeds planted, none germinated (cones probably not mature).

This experiment shows that at least some of the seeds of *P. contorta* (var. *Murrayana*?) are capable of germination after retention in the cones for nine or ten years.

My interest having been aroused in this subject while in California, I was led to observe more closely the cones of our native *P. serotina* on my return to South Carolina and it was soon found that the cones of this species often remain attached and unopen for a much longer time than ever reported. In his "North American Silva," Vol. 3, p. 117, Michaux says:

The cones arrive at maturity the second year, but do not release their seeds before the third or fourth.

Sargent follows this statement in his "Silva" and Britton says (in "North American Trees") that the cones "remain closed for several years before dropping the seed." In the neighborhood of Hartville, South Carolina, it was not at all uncommon to find cones that had remained unopened for ten or even more years, and the opportunity was taken to collect cones of different ages for a test of the viability of the seeds. The cones were taken to the New York Botanical Garden and there the test was made in June of this year. Seeds that were obviously blasted or dead (as shown by floating in water) were discarded, and are recorded as "rejected"; only apparently sound seeds were planted. The seeds were first germinated between filter paper in *Sphagnum* moss for about five days until the radicals appeared. A count was then made and the result recorded in the columns of June 29 in the table below.⁶ All the seeds, whether germinated or not, were then planted in soil in pots, and

⁶ Cone No. 1 was not included in this count because its seeds were by mistake planted in soil before the count was taken.

the seedlings that appeared were counted on July 12⁷ and July 22, with results as shown in the table below.

Years Old.	Rejected.	Planted.	June 29.	Germinated.	
				July 12.	July 22.
3	31	32	?	27	28
4	10	14	6	9	9
4	6	15	13	9	9
6	7	57	30	40	39
6	0	62	52	51	52
6	7	60	58	53	48
7	3	88	42	50	44
8	7	49	10	34	33
8	5	27	2	15	18
8	3	42	0	31	33
9	5	34	3	2	0
9	2	31	10	16	7
14	32	61	33	24	21
14	2	67	7	11	11

Increased numbers in the later readings are due to delayed germinations: decreased numbers to failure to emerge or to damping off after emergence.

It should be noted that the conditions that exist in these serotinous cones are almost ideal for the preservation of the vitality of the seeds. While some exchange of gases is allowed, the spores of fungi and bacteria are effectually excluded; and most important of all, a sufficient humidity is maintained to prevent a fatal desiccation. That this humidity is due to contact with the moist wood of the live tree is shown by the mechanical opening of the cone through drying when it is removed from the wood, or when the tree dies. This opening, however, is not always either prompt or complete.

⁷ This counting was, in my absence, kindly made by Mr. Fred. J. Seaver.